HIGH PRESSURE FEED PUMP

CROSS REFERENCE TO RELATED APPLICATION

The present application is a continuation of international application PCT/CH02/00374, filed 9 July, 2002, and which designates the U.S. The disclosure of the referenced application is incorporated herein by reference.

BACKGROUND OF THE INVENTION

The present invention relates to a high pressure feed pump of the type which operates according to the reciprocating piston principle. More particularly, a pump of this type may be used to produce the injection pressure in fuel injection systems, for example common rail systems, for internal combustion engines. A high pressure feed pump of the general type is disclosed in EP-A-1 058 001 and corresponding U.S. Patent No. 6,205,980.

High pressure feed pumps of the described type have a high pressure cylinder or plunger cylinder and a cylindrical delivery piston or plunger piston which can be reciprocated therein, the volume of the delivery chamber within the high pressure cylinder being varied by the reciprocating movement of the plunger piston. During a filling stroke of the plunger piston, it is possible to connect the delivery chamber to a reservoir chamber for a delivery medium via a filling valve, in order to fill the delivery chamber whose reciprocating volume is increasing with the delivery medium. During a subsequent delivery stroke with the filling valve closed, the pressure rises in the delivery chamber until a pressure valve opens and as a result connects the delivery chamber to a high pressure chamber, for example the common rail.

The plunger piston is driven by an eccentric drive which comprises an eccentric which is mounted on an eccentric shaft and on which a rolling ring is rotatably mounted. The latter has a cambered circumferential surface to reduce its moment of inertia. During the rotation of the eccentric, the delivery piston, which is pretensioned in the direction toward the eccentric shaft, rests on the rolling ring with a plate-like extension which is provided at that end of said delivery piston. During operation, the rolling ring rotates to and fro and changes its direction of rotation twice per revolution of the eccentric shaft. The design and function of the high pressure pump is further described in EP-A-1 058 001 and corresponding U.S. Patent No. 6,205,980, the disclosures of which are expressly incorporated herein by this reference.

In high pressure feed pumps of the abovementioned type, in particular when they are used for diesel injection systems, the material loads are high in those parts which come into contact with one another between the rolling ring and the delivery piston. As a result, either the delivery pressures which can be achieved with such pumps are limited, or the relevant elements must be designed with large dimensions.

It is therefore an object of the present invention to provide a high pressure delivery pump which overcomes the abovementioned problems.

SUMMARY OF THE INVENTION

The above and other objects and advantages of the present invention are achieved by the provision of a high pressure feed pump which includes a plate-like spring element positioned between the front end of the delivery piston and the rolling ring. The rolling ring has a

cambered circumferential surface, and the spring element rests firstly on the circumferential surface of the rolling ring via a contact surface, and secondly on the front end of the delivery piston via an annular surface.

By this construction, the Hertzian surface stress between the rolling ring and the delivery piston (plunger) is considerably reduced compared with known high pressure feed pumps. This is because load dependent adaptation to the camber of the rolling ring takes place as a result of the plate-like spring element. The contact surface between the rolling ring and the spring element which is moved by the delivery piston also becomes greater as the load becomes greater, which keeps the Hertzian surface stress within acceptable limits, both between the rolling ring and the spring element and also between the latter and the delivery piston, even at very high delivery pressures.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be explained in greater detail using embodiments shown in the drawing, in which, purely diagrammatically:

Fig. 1 shows a transverse section through a high pressure feed pump according to the invention along the section line I-I of Fig. 2;

Fig. 2 shows the high pressure feed pump shown in Fig. 1 in a longitudinal section along the line II-II of Fig. 1;

Fig. 3 shows, partially in section, part of the high pressure feed pump shown in Figs. 1 and 2 having a delivery piston which is of concave shape at the front end and rests on a bucket shaped tappet which at the other end interacts with a rolling ring of a drive shaft;

Fig. 4 shows, in the same representation as Fig. 3, a further embodiment of the high pressure feed pump according to the invention having an adapter head which is movably mounted on a shaft of the delivery piston;

Fig. 5 shows a section along the line V-V of the embodiment shown in Fig. 4; and

Fig. 6 shows, in the same representation as Fig. 3, a further embodiment, in which the front end of the delivery piston is of planar design and the bucket shaped tappet has a concave recess.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Figs. 1 and 2 show a transverse section and a longitudinal section through a high pressure feed pump having a main housing 10, which has a radial chamber into which a high pressure cylinder 12 (also called a plunger cylinder) is positioned. A delivery piston 14 (also called a plunger piston) can move to and fro in the direction of the longitudinal axis 14'.

The high pressure cylinder 12 is clamped with a flange-like extension between the main housing 10 and a valve housing 16. The valve housing 16 is joined to the housing 10 by means of threaded bolts 17. An inlet valve 18 and an outlet valve 20 are provided in the valve housing 16. The inlet valve 18 opens and closes a passage 22 to a storage container for the medium to be delivered, and the outlet valve 20 opens and closes a passage 24 to a high pressure container. In the case of a high pressure injection system for internal combustion engines, fuel such as diesel or gasoline is situated in the storage container, and the high pressure container is, for example, a common rail.

Furthermore, an eccentric drive 26 for driving the delivery piston 14 is arranged in the housing 10 of the

high pressure feed pump. The eccentric drive 26 has a drive shaft 28 which is continuously driven in the direction of the arrow and is mounted in a generally known manner in the housing 10 which includes a cover 32 which closes the latter. Bearings (not shown) may be provided such that the drive shaft 28 can freely rotate about a rotational axis 30.

Between the bearing points 34, 34', the drive shaft 28 bears an eccentric journal 36 which is arranged eccentrically with regard to the rotational axis 30 of the drive shaft 28 and whose center axis 38 runs parallel to the rotational axis 30. A rolling ring 40 is mounted on the eccentric journal 36 in a rotatable manner with respect to the eccentric journal 36. The radially outer circumferential surface 42 of the rolling ring 40 is cambered, that is to say is of convex design, as best seen in Fig. 2.

A through bore 44, in the shape of a circular cylinder, is formed in the high pressure cylinder 12, and the bore **44** is coaxial with the axis **14'**, which preferably extends perpendicular to the rotational axis 30 of the draft shaft. The delivery piston 14 is displaceably guided in the bore with a sliding seal. Its end region facing the drive shaft 28 engages in a bucket shaped tappet 46, on whose base 48 it rests with the front end 50 of a mushroom shaped or plate shaped extension 52. The base 48 of the bucket shaped tappet 46 sits on the rolling ring 40 at the other side. The reference numeral 54 denotes the point of contact or contact area between the rolling ring 40 and the base 48 of the bucket shaped tappet 46. The delivery piston 14 is pretensioned in the direction toward the rolling ring 40 by means of a compression spring 56 which is supported at

one end on the high pressure cylinder 12 and at the other end on the extension 52.

The outer circumferential wall 58 of the bucket shaped tappet 46 is guided in a sliding manner in a radial chamber formed in the housing 10 for sliding movement in the longitudinal direction and hence in the direction of movement of the delivery piston 14. The transverse forces which act on the bucket shaped tappet 46 from the drive shaft 28 and the rolling ring 40 are absorbed by the bucket shaped tappet 46 and are not transmitted to the delivery piston 14, or only to a very small degree.

In order to compress and deliver the delivery medium, the delivery piston 14 is reciprocated up and down by the eccentric drive 26 and the compression spring 56. When the delivery piston 14 moves downward during a filling stroke, the delivery chamber 60 is filled with the delivery medium via the inlet valve 18. When the delivery piston 14 is moved in the upward direction during the following delivery stroke, the pressure in the delivery chamber 60 rises with the inlet valve 18 closed, until the outlet valve 20 opens and as a result connects the delivery chamber 60 to the high pressure container (e.g. a common rail). In the process, the delivery medium is delivered into the high pressure container.

In a manner enlarged with regard to Figs. 1 and 2, Fig. 3 shows the delivery piston 14, the compression spring 56, the bucket shaped tappet 46, the rolling ring 40 and part of the drive shaft 28, which can be driven in the direction of the arrow, having the eccentric journal 36.

The bucket shaped tappet 46 is preferably made from hardened roller bearing steel. The plate shaped base 48 of the bucket shaped tappet 46, which is flat in the

unloaded state, has spring properties and serves as a spring element 62 in its interaction on one side with the cambered circumferential surface 42 of the rolling ring 40 and on the other side with the concavely designed front end 50 of the delivery piston 14. The depression 64 in the end of the delivery piston 14 can be shaped, for example, as a spherical cap or part of the circumferential surface of a torus. Around the depression 64, the front end 50 of the delivery piston 14 has a flat annular surface 66, with which it rests on the base 48 in the unloaded or lightly loaded state and which can have the shape of a circular ring, oval or other shape depending on the shape of the depression 64.

Preferably, the longitudinal axis 14' of the delivery piston 14 should run centrally with respect to the depression 64 or annular surface 66 and with respect to the bucket shaped tappet 46. Furthermore, the axis 14' preferably runs in a plane extending at right angles to the rotational axis 30 of the drive shaft 28, said plane extending centrally through the contact area 54.

The base 48, acting as a spring element 62, of the bucket shaped tappet 46 is deformed into the depression 64 as a function of the loading of the delivery piston 14 in such a way that, when the load becomes greater, firstly the contact area 54 between the base 48 and the rolling ring 40 and secondly the area over which the base 48 rests on the delivery piston 14 are enlarged. As a result, the Hertzian surface stress in the relevant parts is kept within limits which permits a long service life of the high pressure feed pump. The base 48 is preferably dimensioned in such a way that its entire area rests in the depression 64 on the delivery piston 14 in the case of a specific load.

In the embodiment shown in Figs. 4 and 5, only the delivery piston 14 is different in comparison with the embodiment shown in Figs. 1 to 3. The functioning is the same as described further above. There is therefore only a detailed description of the delivery piston 14.

The delivery piston 14 shown in Figs. 4 and 5 has a shaft 68, on whose end region, which is shaped like a hemisphere and faces the rolling ring 40, sits an adapter head 70 of substantially circular cylindrical shape. The front end 50, which interacts with the base 48 of the bucket shaped tappet 46, of the head adapter 70 is of the same design as that in the case of the delivery piston 14 according to Fig. 3. A recess 72 of the adapter head 70 for accommodating the end region of this side of the shaft 68 is shaped to be diametrically opposed to said end region and has a peripheral groove 74 in a cylindrical outer part adjoining the hemispherical surface.

The shaft 68 is correspondingly provided with a circumferential groove 76. As best seen in Fig. 5, a rectilinear through hole 78 runs through the adapter head 70, whose axis is tangent to the circular center line of the toroidal chamber delimited by the groove 74 and the circumferential groove 76. A section of a securing element formed from spring steel wire 80 extends through the through hole 78, and a further section of said securing element extends around the adapter head 70 in order to fasten it. In this manner, the adapter head 70 is mounted on the shaft 68 in the manner of a sphere with limited mobility. This makes it possible for exclusively axial forces and no bending forces to act on the delivery piston 14.

The compression spring 56 is supported on a flange ring 82 which engages around two half flanges 84 and is

for its part supported on the latter. A bead 86 of the half flanges 84 engages in a circumferential groove of the shaft 68 and the half flanges 84 are attached in this way to the shaft 68 in the axial direction.

The embodiment shown in Fig. 6 of the high pressure feed pump according to the invention is very similar to that according to Fig. 3, the front end 50 of the delivery piston 14 being of flat design and the base 48 of the bucket shaped tappet 46 being of concave shape as a result of a recess 64' on the side facing the delivery piston 14. Here too, the delivery piston 14 rests in the unloaded and lightly loaded state with an annular surface 66 on the base 48, acting as a spring element 62, of the bucket shaped tappet 46. The method of operation is the same as described further above in conjunction with the other embodiments.

In the embodiment shown in Fig. 6, the delivery piston 14 can be of the same design as shown in Fig. 3 or 4. The transition between the annular surface 66 and the depression 64' is itself preferably shaped in a manner corresponding to the spring characteristic of the spring element 62, such that the area with which the spring element rests on the delivery piston is continuously enlarged as the load rises.

The depression 64' can be matched to the camber of the rolling ring 40 in such a way that, when at least approximately the whole area of the spring element 62 rests in the depression 64', the spring element 62 also rests on the rolling ring 40 across at least approximately the whole width of the latter.

Many modifications and other embodiments of the inventions set forth herein will come to mind to one skilled in the art to which these inventions pertain having the benefit of the teachings presented in the

foregoing descriptions and the associated drawings. Therefore, it is to be understood that the inventions are not to be limited to the specific embodiments disclosed and that modifications and other embodiments are intended to be included within the scope of the appended claims. Although specific terms are employed herein, they are used in a generic and descriptive sense only and not for purposes of limitation.